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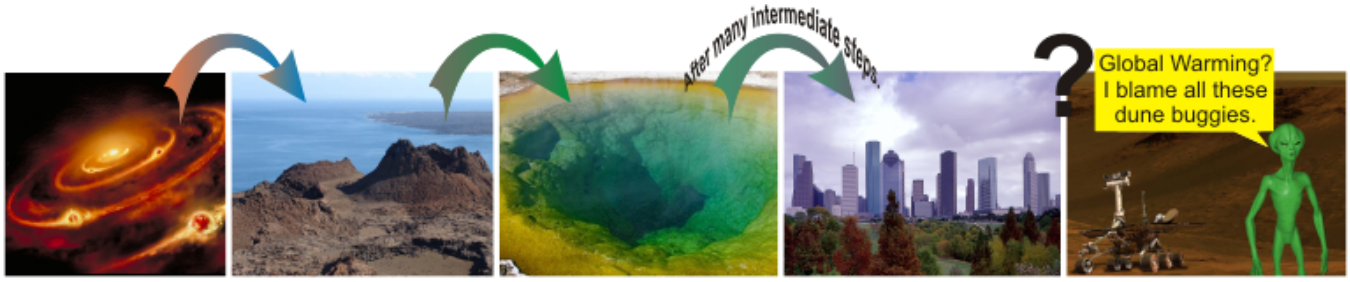

Astronomy 100 - Exploring the Cosmos

Fall Semester 2014

Life in the Universe

Overview of the Course

Astronomy 100 is a seminar course primarily intended for first year undergraduate students interested in science or engineering, and particularly recommended for those potentially interested in astronomy and astrophysics. However, the course is designed to be accessible to all students, and all students are welcome. The theme changes from time to time, selected from among topics of modern cosmic physics with the aim of introducing important concepts, methods and discoveries interesting to a wide range of students. The topic for fall 2014 is *Life in the Universe*

Overview of the Fall 2014 Semester Topic

We know for sure that life exists in the universe, but, thus far, we know only one example of it, on one planet **. . .** our own.

Looking beyond Earth, the part of our universe that we can see contains about 10^{22} stars. Observations of relatively nearby stars – a mere handful in comparison with the total – confirm that a large fraction of stars have planets orbiting them. Although many of those planets are substantially different from Earth, including in their likely potential to harbor life, increasingly sensitive observations are revealing more and more planets that resemble our own.

Earth formed about 4.54 billion years ago, contemporaneously with the Sun, and about 9 billion years after what is thought to have been the formation of our universe. Cellular life apparently developed on Earth between 3½ and 4 billion years ago, remarkably soon after the formation. Abundant, multicellular and multivarious, hard-shelled, fossil-leaving organisms date back to as early as 542 million years before the present, though soft-bodied multicellular organisms predate that. Early dinosaurs appeared around 230 million years ago, had developed into the dominant large terrestrial life form by about 200 million years ago, and suddenly became extinct about 65 million years ago (except for some of the smaller dinosaur species that survived through the extinction event and evolved into what, today, we call birds). Compelling evidence indicates that that extinction event, which is usually referred to as the Cretaceous-Tertiary, or K-T, extinction, was caused by the impact of a comet or moderate-sized asteroid. During the ascendency of the dinosaurs, few mammals larger than today's small rodents existed. (The largest known Cretaceous-era mammal, Repenomamus gigantus, resembling a present-day Tasmanian Devil, probably maxed out at about 30 lbs. Apparently dinosaurs were such effective predators, that nutritiously attractive mammals that

grew to noticeable size were, for the most part, eaten more rapidly than they were able to reproduce.) Following the extinction of dinosaurs, the evolutionary check on mammals was removed, opening an ecological niche for the development of large mammals **. . .** from one branch of which humans eventually evolved. The early erect primate ancestors of humans seem to have appeared on Earth over a period of time some 4 to 6 million years ago, with uncertainties driven to a large extent by sparseness in the still-to-be-fully-uncovered fossil record, as well as by ambiguities inherent in marking specific transitions in a more or less continuous line of evolutionary development. Modern humans evolved from those hominid ancestors, and had begun to develop recognizably modern urban-concentration lifestyles by about 10,000 years ago.

The prevalence and nature of other life in other places in the universe has been a subject of discussion and speculation for at least several thousand years. One early record of such discussion was left by the Greek philosopher Epicurus, who lived during the third and fourth centuries BC. Although, today, Epicurus seems to be remembered in popular culture mainly as a proponent of sensual pleasure, especially good food, his range was considerably wider and deeper. Epicurus was an atomistic materialist, who held that all of reality is a result of the physical properties of matter and energy, and that matter itself consisted of tiny, indivisible atoms. Epicurus opposed the popularly reigning beliefs and doctrines based in superstition and magic. On the subject of life in the universe, Epicurus, some two and a half millennia ago, wrote, in his *Letter to Herodotus* (apparently one of his followers; the famed Herodotus, "Father of History", died a century earlier):

> There are infinite worlds both like and unlike this world of ours. For the atoms, being infinite in number **. . .** are borne out far into space **. . .** and have not been used up, either on one world or a limited number of worlds. So there nowhere exists an obstacle to the infinite.
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> Epicurus in "Letter to Herodotus", ca. 300 BC
> Quoted from *Plurality of Worlds:* **. . .**
> S.J. Dick, Cambridge University Press, 1982

More recently, some 800 years ago in China, the philosopher-poet Teng Mu wrote:

> Heaven and earth are large, and yet in the whole of empty space they are but a small grain of rice **. . .** It is as if the whole of empty space were a tree and heaven and Earth were one of its fruits. Empty space is like a kingdom, and heaven and earth no more than a single **. . .** person **. . .** Upon one tree there are many fruits, and in one kingdom many people. How unreasonable it would be to suppose that besides the heaven and earth that we can see, there are no other heavens and no other earths.
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> Teng Mu in "Po Ya Chin ("The Lute of Po Ya")
> ca. 13th century. Quoted in *Science and Civilization in China*
> J. Needham, Cambridge University Press, 1959

Epicurus's and Teng Mu's arguments for the widespread prevalence of planets and life in our universe were based, respectively, in logic and analogy. Present-day discussions about the prevalence of life elsewhere in the universe still contain hefty appeals to logic and analogy. But more than that, today, while we still confront vast gaps in our understanding, we also possess hefty knowledge about the nature of the universe and the nature of life, as well as capabilities for observation, exploration, and measurement, not even dreamt in centuries past.

This seminar explores the knowledge and ideas that propel current-day scientific investigations -- and speculations -- into the prevalence and nature of planetary systems and life in the universe.

Instructor

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Class Structure

This seminar course meets one hour per week. As a seminar, this course entails high degrees of student participation. Much of the in-class time will be devoted to prepared student presentations of the material accompanied by class discussion. These presentations are expected to be well prepared and illustrated; PowerPoint projection will be available in the room and students should plan on using it. Class material will be drawn from the text(s), from other published literature, and from the web. Occasionally the instructor may need to be absent for an out-of-town meeting; on such occasions a guest lecturer or instructor may be invited.

Time & Place

Thursdays / 4:00pm – 5:00pm / Herman Brown Hall 427

Text & Materials

The course will, in addition to other library and online sources, draw heavily on the material from the required textbook:

Life in the Universe, Jeffrey Bennett & Seth Shostak, 3rd Edition, Addison-Wesley, 2012.

In preparing presentations or further pursing topics of special interest to them, students are encouraged consult other source material. Numerous sources in the library or on the web will be helpful as well. Published materials should be approached with a critical eye, whether in the library or on the web, but especially on the free-for-all web.

Additional reference sources are listed or linked in the "Resources, et cetera" section on the class website.

Class Website & Syllabus

Class website is most easily linked from: **http://ehl.web.rice.edu/**

Students are responsible for being familiar with the content of this syllabus as well as the content of the website, which is likely to evolve during the semester. Updates of this syllabus will be available on the website. The syllabus is intended to convey a general overview of the course content, expectations, practices and policies. The list of topics and timings given will likely be adjusted as the course proceeds, and syllabus is subject to minor alteration in other respects.

Grading

Grades will be based on a combination of class presentations and participation and a final class essay paper. More details will be announced.

Topics to be Covered

The table shows the roughly anticipated class-subject schedule based on 13 class weeks beyond the first week.

General Topics List
Life in the Universe
Science of Life in the Universe
Universal Context of Life
Habitability of Earth
Nature of Life on Earth
Origin & Evolution of Life on Earth
Searching for Life in the Solar System
Mars
Life on Jovian Moons(?)
Nature & Evolution of Habitability
Habitability Outside the Solar System
Search for Extraterrestrial Intelligence
Interstellar Travel & the Fermi Paradox

Class Attendance

Students are expected to be present for all classes. This is a seminar class, with grades dependent in significant measure on participation. Students with circumstances unavoidably affecting their attendance – including formal athletics commitments – should consult with the instructor well before their attendance is compromised.

Honor Code, Collaboration & Citation Policies

In preparing class presentations, whether individual or collaborative, students may consult any materials and discuss freely with others. In preparing a final class paper, students may again consult any materials of their choosing, and freely engage conversations. However, the writing of the paper is to be the sole and individual work of the student, and subject to the Rice Honor Code. In all work, students are expected to be scrupulous about proper citation of sources, as required both as a matter of integrity and formally as a part of the Rice Honor Code.

Disabilities & Accommodations

The University seeks to foster an environment of broad access and feasibly equal opportunity to education. The Office of Disability Support Services (DSS; Allen Center, Room 111; 713-348-584; adarice@rice.edu) supports and implements federal guidelines under the Rehabilitation Act of 1973 and the Americans with Disabilities Act. Students with documented disabilities requiring accommodation under Rice's established policies should consult DSS and the instructor; all such consultations and accommodations will be held confidential to the extent feasible.

Machines in the Classroom

Cell phones must be turned off – or rendered silent – within the classroom. If you need to take an urgent call, please set your phone to vibration and take the call outside the room. Laptops or other small devices may be used in class only for specific class purposes. If you have an urgent need to be online during the class time, feel free to do so **. . .** but elsewhere.

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